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Studies on influence of season for biochemical parameters in mango cultivars

M. Kumar[1]*, V. Ponnuswami[1], P. Jeyakumar[2], R. Richard Kennedy[1] and S. Saraswathy[1]

[1]Horticultural College and Research Institute, Periyakulam, Tamil Nadu, India-625604, India.
[2]Department of Crop Physiology, TNAU, Coimbatore-3, India.

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Mango flowering is predominantly influenced by the biochemical constituents present in the phase for the floral stimuli at bud break stage. The state of biochemical constituents primarily determines the synchronizing of flower stimuli and earliness of flowering. The results of this experiment have clearly indicated that all the biochemical constituents in leaves and shoot at vegetative stage, flowering stage and harvesting stage were significantly influenced by location, season and varieties individually or in combination. The leaf nutrient status is the indication of the healthy status of tree vigour. The environmental variables play a key and vital role in induction of mango flowering. Experimental evidence indicates that maturity of terminal shoot and accumulation of carbohydrate in the leaves and shoot apex are in some way associated with the synthesis of the floral stimulus in mango trees. The results revealed that by the Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam during the year 2010 to 2012. Field experiments were carried out to study the response of seasons in mango cultivars. The results revealed that the highest nitrogen content of leaf and shoot at vegetative stage (1.46 and 1.45%), flowering stage (1.54 and 1.52%) and harvesting stage (1.48 and 1.36%) was in cv. Neelum during Main season. The highest carbohydrate content of leaf and shoot at vegetative stage (20.40 and 20.17%), flowering stage (21.60 and 24.04%) and harvesting stage (17.95 and 19.85%) was in cv. Neelum during Main season and the highest carbohydrate/ nitrogen ratio of leaf and shoot at vegetative stage (13.93 and 13.84), flowering stage (13.95 and 16.16) and harvesting stage (12.13 and 15.17) was in cv. Neelum during main season.

Key words: Biochemical parameters, mango cultivars, season, varieties.

INTRODUCTION

Mango (*Mangifera indica* L.) belonging to the family Anacardiaceae occupies a predominant place among the fruit crops grown in India and christened as the 'King of fruits' owing to its delicious flavour and taste. In India, mango is cultivated in an extent of about 2.3 million hectares with the production of 15.27 million metric tonnes (Indian Horticulture Database, 2010 - 11). The National average productivity of mango in India is 6.6 tonnes per hectare. In Tamil Nadu, mango is grown in an area of about 1, 48,000 ha with the production of 823,000 MT of fruits and the productivity is about 5.60 MT per hectare (Indian Horticulture Database, 2010-11). Normally mango flowering occurs during the month of December to January and fruiting takes place during April to May in Indian conditions. However, in certain pockets of Southern Tamil Nadu *viz.,* Tenkasi and Senkottai

*Corresponding author. E-mail: kumshorts@gmail.com. Tel: 09788677392.

blocks of Thirunelveli district and Agasteeswaram block of Kanyakumari district, mango produces off - season bearing and the flowering occurs during July to August and fruiting commences during November to December. This peculiar phenomenon of flowering and fruiting in mango is known as off-season bearing. Flowering is the first of several events that set the stage for mango production each year. Given favorable growth conditions, the timing and intensity of flowering greatly determines when and how much fruits are produced during a given season. Insight into this phenomenon has been of prime interest to scientists and growers for over a century. As a consequence of efforts to elucidate the mechanisms of this critical biological event in mango and other model plant systems, many of the important details are becoming clearer at the molecular, biochemical, and physiological levels resulting in a better understanding of how to manage flowering in the field. A conceptual flowering model has been described to explain the interaction of internal and external factors regulating vegetative and reproductive shoot initiation and induction in mango trees growing in tropical and subtropical environments (Davenport and Nunez-Elisea, 1997). Keeping in view of above season influences a study was undertaken with the objective to explore the potentiality of climatic factors as influences of season for biochemical parameters in mango cultivars.

MATERIALS AND METHODS

An experiment was conducted at State Horticultural Farm, Kanyakumari District was undertaken by the Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam during the year 2010 to 2012. The experiment was laid out in a Factorial Randomized Block Design (FRBD), with two seasons and ten varieties and replicated twice. Ten year old trees of mango cultivars were selected for this study. Ten mango cultivars selected for this study are Alphonso, Bangalora, Kalepad, Himayuddin, Sendura, Mulgoa, Neelum, Rumani, Banganapalli and Swarnarekha and seasons are main and off-season. The weather parameters *viz.*, Maximum and minimum temperature, relative humidity, average rainfall in Kanyakumari, were recorded in experimental location.

Leaf and shoot sample collection

The third leaf of the fully grown terminal shoots of the mango varieties were collected at random from each treatment as suggested by Pathak and Pandey (1978). The samples were collected and the nutrient content was estimated at vegetative, flowering and harvesting stage. The samples were dried in shade and then in oven at 60^{o}C for 3 h. The dried leaves and shoots were finely powdered using a mixture cum grinder and kept for leaf nitrogen analysis.

Nitrogen content

The nitrogen content in leaf and shoot sample was estimated by Micro - Kjeldahl method suggested by Humphries (1956) and the mean value was expressed in percentage.

Total carbohydrate

The total carbohydrate content in fresh leaf and shoot sample was estimated calorimetrically by following the procedure of Somogyi (1952) and the mean values were expressed in percentage.

Carbohydrate - nitrogen ratio

The carbohydrate: nitrogen ratio in leaf was derived by dividing the total carbohydrate content by the total nitrogen content.

RESULTS AND DISCUSSION

Mango flowering is predominantly influenced by the biochemical constituents present in the phase for the floral stimuli at bud break stage. The state of biochemical constituents primarily determines the synchronizing of flower stimuli and earliness of flowering. The results of this experiment have clearly indicated that all the biochemical constituents in leaves and shoot at vegetative stage, flowering stage and harvesting stage were significantly influenced by season and varieties. In the current investigation, all the varieties and season had a significant effect on the leaf and shoot nutrient content *viz*., Nitrogen, Carbohydrate and Carbohydrate - Nitrogen ratio at vegetative, flowering and harvesting phase. The highest nitrogen content of leaf at vegetative stage (1.46%) was in cv. Neelum during Main season followed by cv. Neelum during off season which recorded 1.40%. The lowest value (1.19%) was noticed in cv. Rumani during off season. The highest nitrogen content of leaf at flowering stage (1.54%) was in cv. Neelum during Main season followed by cv. Kalepad during off season which recorded 1.48%. The lowest value (1.22%) was noticed in cv. Rumani during off season. The highest nitrogen content of leaf at harvesting stage (1.48%) was in cv. Neelum during Main season followed by cv. Neelum during off season which recorded 1.40%. The lowest value (1.17%) was noticed in cv. Rumani during off season (Table 1). This might be due to the leaf nutrient status is the indication of the healthy status of tree vigour. The earlier research in mango revealed that the existence of floral stimulus, which is continuously synthesized in mango leaves and shoot during the conducive climate conditions prevailed (Davenport and Nunez-Elisea, 1990). Mango leaves and shoot appeared to be the only site where the putative floral stimulus is produced (Nunez-Elisea and Davenport, 1991). The already available evidence suggested that in fruit plants, the nutrient content of reserves play an important and critical role in flower bud initiation (Singh, 1978). It is quite probably that accumulation of nutrients may create favorable and congenial condition for synthesis and action of the requested substances responsible for flowering.

Table 1. Influence of season for Nitrogen content of leaf in mango cultivars.

Varieties	Nitrogen content of leaf at vegetative stage		Nitrogen content of leaf at flowering stage		Nitrogen content of leaf at harvesting stage	
Seasons	**Main season**	**Off season**	**Main season**	**Off season**	**Main season**	**Off season**
Alphonso	1.29	1.25	1.38	1.28	1.26	1.17
Bangalora	1.31	1.27	1.43	1.38	1.35	1.30
Kalepad	1.35	1.32	1.48	1.43	1.38	1.33
Himayuddin	1.29	1.26	1.36	1.26	1.32	1.25
Sendura	1.27	1.23	1.31	1.25	1.28	1.23
Mulgoa	1.29	1.24	1.28	1.23	1.26	1.21
Neelum	1.46	1.40	1.54	1.43	1.48	1.40
Rumani	1.22	1.19	1.25	1.22	1.21	1.17
Banganapalli	1.34	1.31	1.36	1.26	1.34	1.30
Swarnarekha	1.27	1.22	1.30	1.22	1.29	1.25
SEd	0.00450		0.00358		0.00444	
CD (0.5%)	0.00910		0.00724		0.00898	

Table 2. Influence of season for Nitrogen content of shoot in mango cultivars.

Varieties	Nitrogen content of shoot at vegetative stage		Nitrogen content of shoot at flowering stage		Nitrogen content of shoot at harvesting stage	
Seasons	**Main season**	**Off season**	**Main season**	**Off season**	**Main season**	**Off season**
Alphonso	1.22	1.18	1.28	1.24	1.18	1.12
Bangalora	1.30	1.23	1.31	1.28	1.24	1.17
Kalepad	1.35	1.27	1.38	1.31	1.28	1.21
Himayuddin	1.23	1.17	1.27	1.23	1.21	1.16
Sendura	1.23	1.20	1.23	1.21	1.16	1.11
Mulgoa	1.21	1.17	1.23	1.19	1.14	1.05
Neelum	1.45	1.40	1.52	1.45	1.36	1.25
Rumani	1.17	1.15	1.23	1.19	1.14	1.05
Banganapalli	1.25	1.21	1.28	1.23	1.24	1.19
Swarnarekha	1.17	1.14	1.19	1.16	1.13	1.04
SEd	0.00441		0.00473		0.00336	
CD (0.5%)	0.00893		0.00958		0.00679	

The highest nitrogen content of shoot at vegetative stage (1.45 %) was in cv. Neelum during Main season followed by cv. Neelum during off season which recorded 1.40%. The lowest value (1.14%) was showed in cv. Swarnarekha during off season. The highest nitrogen content shoot at flowering stage (1.52%) was in cv. Neelum during Main season followed by cv. Neelum during off season which recorded 1.45%. The lowest value (1.16%) was observed in cv. Swarnarekha during off season. The highest nitrogen content shoot at harvesting stage (1.36%) was in cv. Neelum during Main season followed by cv. Kalepad during Main season which registered 1.28% (Table 2). This might be due to the nitrogen and carbohydrate reserves played a critical role in flower bud initiation though they did not form the primary cause and that the accumulation of these compounds might create a favourble congenial environmental condition for the synthesis and action of the substances that are actually responsible for flower induction in mango. This was in conformity with the findings of Singh (1961).

The highest carbohydrate content of leaf at vegetative stage (20.40%) was in cv. Neelum during Main season followed by cv. Neelum during off season which recorded 19.23%. The lowest value (10.13%) was noticed in cv. Mulgoa during off season. The highest carbohydrate content of leaf at flowering stage (21.60%) was in cv.Neelum during Main season followed by cv. Neelum

Table 3. Influence of season for carbohydrate content of leaf in mango cultivars.

Varieties	Carbohydrate content of leaf at vegetative stage		Carbohydrate content of leaf at flowering stage		Carbohydrate content of leaf at harvesting stage	
Seasons	**Main season**	**Off season**	**Main season**	**Off season**	**Main season**	**Off season**
Alphonso	13.67	12.31	15.15	13.71	12.96	12.15
Bangalora	15.25	14.30	18.30	17.70	15.34	14.50
Kalepad	16.57	15.65	19.30	18.10	16.35	15.10
Himayuddin	14.65	14.01	14.92	14.18	13.17	12.25
Sendura	14.45	13.80	16.25	15.32	13.70	12.90
Mulgoa	11.57	10.13	13.86	12.93	12.40	11.35
Neelum	20.40	19.23	21.60	19.75	17.95	16.95
Rumani	14.34	13.85	14.83	14.35	13.30	12.75
Banganapalli	14.80	13.85	16.35	15.55	15.22	14.31
Swarnarekha	13.80	13.15	14.10	13.75	13.00	12.10
SEd	0.05013		0.05120		0.03811	
CD (0.5%)	0.10141		0.10355		0.07708	

Table 4. Influence of season for carbohydrate content of shoot in mango cultivars.

Varieties	Carbohydrate content of shoot at vegetative stage		Carbohydrate content of shoot at flowering stage		Carbohydrate content of shoot at harvesting stage	
Seasons	**Main season**	**Off season**	**Main season**	**Off season**	**Main season**	**Off season**
Alphonso	13.61	12.26	16.80	15.90	13.75	11.76
Bangalora	16.40	15.31	21.19	19.52	15.67	14.40
Kalepad	17.95	16.35	22.30	20.50	16.50	15.20
Himayuddin	13.65	12.85	14.40	13.67	12.62	11.60
Sendura	14.75	13.88	15.50	14.81	13.26	12.30
Mulgoa	12.58	10.35	15.05	13.90	11.89	9.87
Neelum	20.17	18.35	24.04	22.26	19.85	19.05
Rumani	14.17	13.15	15.30	14.66	12.95	11.91
Banganapalli	15.60	14.25	16.65	15.80	14.58	13.82
Swarnarekha	13.55	13.57	14.70	14.10	13.45	12.40
SEd	0.05272		0.06946		0.05283	
CD (0.5%)	0.10664		0.14050		0.10686	

during off season which recorded 19.75%. The lowest value (12.93%) was registered in cv. Mulgoa during off season. The highest carbohydrate content of leaf at harvesting stage (17.95%) was in cv.Neelum during Main season followed by cv. Neelum during off season which registered 16.95% (Table 3).

The highest carbohydrate content of shoot at vegetative stage (20.17%) was in cv. Neelum during Main season followed by cv. Neelum during off season which recorded 18.35%. The lowest value (10.35%) was noticed in cv. Mulgoa during off season. The highest carbohydrate content of shoot at flowering stage (24.04%) was in cv.Neelum during Main season followed by cv. Neelum during off season which registered 22.30%. The highest carbohydrate content of shoot at harvesting stage (19.85%) was in cv.Neelum during Main season followed by cv. Neelum during off season which recorded 19.05% (Table 4).

The highest carbohydrate / nitrogen ratio leaf at vegetative stage (13.93) was in cv.Neelum during Main season followed by cv. Neelum during off season which recorded 13.74. The lowest value (8.15) was exhibited in cv. Mulgoa during off season. The highest carbohydrate / nitrogen ratio of leaf at flowering stage (13.95) was in cv.Neelum during Main season followed by cv. Neelum during off season which recorded 13.79. The lowest value (10.49) was registered in cv. Mulgoa during off season. The highest carbohydrate / nitrogen ratio of leaf

Table 5. Influence of season for C/N ratio of leaf in mango cultivars.

Varieties	C/N ratio of leaf at vegetative stage		C/N ratio of leaf at flowering stage		C/N ratio of leaf at harvesting stage	
Seasons	**Main season**	**Off season**	**Main season**	**Off season**	**Main season**	**Off season**
Alphonso	10.53	9.82	10.92	10.71	10.25	10.34
Bangalora	11.58	11.27	12.78	12.82	11.35	11.14
Kalepad	12.23	11.89	13.03	12.61	11.83	11.34
Himayuddin	11.36	11.11	10.92	11.18	9.95	9.79
Sendura	11.35	11.18	12.37	12.25	10.66	10.48
Mulgoa	8.82	8.15	10.78	10.49	9.83	9.33
Neelum	13.93	13.74	13.95	13.79	12.13	12.11
Rumani	11.69	11.62	11.82	11.76	10.95	10.84
Banganapalli	11.02	10.57	11.95	12.28	11.31	11.00
Swarnarekha	10.82	10.75	10.84	11.20	10.05	9.65
SEd	0.02795		0.02145		0.01672	
CD (0.5%)	0.05654		0.04338		0.03381	

at harvesting stage (12.13) was in cv.Neelum during Main season followed by cv. Neelum during off season which recorded 12.11 (Table 5). The conformity result the seasonal changes had influence in the carbohydrate reserves and nitrogen content of leaf and shoots and their relationship with flower bud differentiation of mango. These findings are in corroboration with those of Mallik (1953). In almost all the mango cultivars studied, except in “Baramasi” it was found that higher starch reserves, total carbohydrate, nitrogen and high carbohydrate – nitrogen ratio in the leaves and shoots favoured flower initiation in mango. Chemical constituents of leaves and shoots observed in the present study, revealed that a higher starch reserves and total carbohydrates and carbohydrate – nitrogen ratio at the critical time of fruit bud differentiation period appeared to favour flower bud formation and amongest these factors greater accumulation of starch at differentiation period seemed to be the most important factor responsible for flower bud formation. This result was in accordance with the findings of Singh (1960).

The highest carbohydrate / nitrogen ratio of shoot at vegetative stage (13.84) was in cv.Neelum during Main season followed by cv. Kalepad during Main season which recorded 13.27. The lowest ratio (8.83) was observed in cv. Mulgoa during off season. The highest carbohydrate / nitrogen ratio of shoot at flowering stage (16.16) was in cv. Bangalora during Main season followed by cv. Kalepad during Main season which recorded 16.13. The lowest value (11.10) was observed in cv. Himayuddin during off season. The highest carbohydrate / nitrogen ratio of shoot at harvesting stage (15.17) was in cv. Neelum during off season followed by cv. Neelum during Main season which recorded 14.60 (Table 6). This might be attributed due to environmental factors and seasonal changes in biochemical composition viz., nitrogen content, carbohydrate level and carbohydrate – nitrogen ratio. The role of carbohydrates, nitrogen, carbohydrate – nitrogen ratio, protein and amino acids. This suggests that flower bud initiation and differen-tiation have a positive association with accumulation of carbohydrate and nitrogen content in leaves. These findings were also supported by Venkatesan (2006) in mango. Thus, it could be concluded that high metabolic activity and continuous production of a many of vegetative flushes, which mature at different times of the year, make off – season flowering possible in mango. The leaves/shoots with higher starch, total carbohydrate and C/N ratio content favour flower initiation (Sen, 1943). Flowering has been thought to be regulated by C/N ratio and seasonal changes in this ratio were generally very much important which determine fruit bud differentiation in mango (Naik and Rao, 1943; Kraus and Kraybill, 1981). The decreasing ratio from harvesting stage onwards coincided with fruit developed period. The decrease in leaf nitrogen content close to panicle bearing set fruits were associated with a decrease in leaf carbohydrate concentration, probably as a sequence of an increased demand for both nitrogen and energy of the developing fruits (Urban et al., 2004). Similar findings were also supported by Jayavalli (2006) and Gnanasekaran (2007).

The fundamental principle under laying this model is that the fruit yield is the products of photo assimilate (carbohydrate) accumulation and subsequent redistribution during the annual weather and growth cycle. Accumulation of photo assimilates would drive critical growth events that require higher levels of resources than are available from current photo assimilate supplies. Cultivars that proceed with balanced

Table 6. Influence of season for C/N ratio of leaf in mango cultivars.

Varieties	C/N ratio of shoot at vegetative stage		C/N ratio of shoot at flowering stage		C/N ratio of shoot at harvesting stage	
Seasons	**Main season**	**Off season**	**Main season**	**Off season**	**Main season**	**Off season**
Alphonso	11.13	10.32	13.06	12.82	11.62	10.47
Bangalora	12.60	12.39	16.16	15.25	12.56	12.26
Kalepad	13.27	12.80	16.13	15.59	12.87	12.57
Himayuddin	11.09	10.93	11.32	11.10	10.34	9.95
Sendura	11.94	11.55	12.52	12.23	11.34	11.09
Mulgoa	10.29	8.83	12.20	11.60	10.34	9.42
Neelum	13.84	13.07	15.72	15.34	14.60	15.17
Rumani	12.05	11.36	12.46	12.32	11.32	11.38
Banganapalli	12.45	11.71	13.00	12.82	11.72	11.55
Swarnarekha	11.59	11.79	12.30	12.15	11.83	11.99
SEd	0.02576		0.03462		0.03036	
CD (0.5%)	0.05210		0.07002		0.06141	

reproductive, vegetative and rest phases are more likely to have sufficient carbon resources reserves to meet periods of critical demand and therefore will sustain higher yields. This fact was in accordance with the findings of Cull (1991).

Environmental conditions, such as water stress, cool temperatures, high evaporative demand, flooding, girdling and other events that inhibit and distinct vegetative growth result in a shift in carbohydrate partitioning and a diversion of soluble assimilates to stem apices. The elevated carbohydrate status in bud, together with a floral stimulus, results in floral induction of crop phase. Vigorously growing cultivars and juvenile plants have low starch reserves (Whiley et al., 1991) and a diversion of these soluble assimilates from stem apices results in floral inhibition. Flower growth is initially dependent on carbohydrates reserves in the tree and the carbohydrate reserves and leaf assimilates produced by leaves, from the time they balance their carbohydrate demand (Hansen, 1971). However, recent research revealed that flowers themselves are able to photosynthesis and contribute significant to their carbohydrate and nitrogen balance from bud burst to fruit setting (Vemmos and Goldwin, 1993). Carbohydrates play vital role in flower development and fruit setting (Vemmos, 1995).

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